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ABSTRACT

This report analyzes the nonverbal performance of 100 children (3 1/2-4 1/2 year old) on tasks of discontinuous quantity. The children are part of a larger group of subjects participating in a longitudinal study of educational and social programs for disadvantaged children currently being conducted by the Educational Testing Service. The purposes of the analysis are: to examine and describe some psychometric properties of measures appropriate for use with very young children; to relate the measures to theory in developmental psychology; and to consider some implications for educational research and practice. The two principal measures are a spontaneous correspondence task and a test of spatial enumeration, with a third supplementary test of counting. The results suggest the feasibility of measures of quantitative thinking which are less dependent on verbal responses and which attempt to focus on the processes of responding. (Author/AJ)

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Understanding of Quantitative Concepts in $3\frac{1}{2}$-$4\frac{1}{2}$ Year-Old Children

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Educational Testing Service

(Paper presented to the American Educational Research Association, Minneapolis, Minnesota, March 3, 1970).

Many of the traditional measures of the young child's quantitative abilities require the explicit use of numbers and quantitative terms. These measures offer some idea of how closely the young child's thought approximates that of the older child or adult. However, developmental research on quantitative thinking, such as studies of spatial enumeration and Piaget's studies, show that the correct use of numbers and quantitative terms is a by-product of more basic early cognitive accomplishments. A concern for appraising distinct components of early quantitative thinking led to the development of several measures appropriate for use with very young children. One purpose of the present analysis is to examine and describe some psychometric properties of these measures. A second purpose is to relate the measures to theory in developmental psychology. In addition, some implications for educational research and practice are considered. The two principal measures are a spontaneous correspondence task and a test of spatial enumeration, with a third supplementary test of counting.

The present analysis is based on a sample of 100 children ($3\frac{1}{2}$-$4\frac{1}{2}$ years old) who were individually tested last year. They are part of a larger group of subjects participating in a longitudinal study of educational and social programs for disadvantaged children currently being conducted by ETS under a grant from the Office of Child Development, Dept. of Health, Education and Welfare.

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Description of Measures

Spontaneous Correspondence. The Spontaneous Correspondence Task is an adaptation of the procedure described by Piaget in his book on number (1952). In the present version, the examiner sets out an array of 1 x 1 inch ceramic tiles and simply asks the child to "put out the same number" or "just as many" tiles. The task is repeated four times; twice with 7 tiles, once with 8 tiles and once with 10 tiles. In three of the presentations, the tiles are arranged in a line; a random pattern is used for one item. This task was selected for inclusion in the initial battery of tests because of its close relationship to Piaget's task on number conservation, a version of which is to be included in the battery for older children.

Enumeration Task. The general procedure of the Enumeration Task is similar to that reported by Potter and Levy (1968). The child is asked to point to each figure on a page of a test booklet once and once only. No verbal response is requested. The figures, consisting of colored circles, are arranged in 3 types of arrays: single lines, rows, and random configurations. There are 12 items in all with 6, 7, or 9 figures for each item.

Counting. At the conclusion of the Enumeration test the child was shown a row of 7 figures and was asked to count them aloud. This is identified as the "counting" task.

Results

In presenting the results, each task will be reported on separately, followed by a discussion of the relationships between them.

Spontaneous Correspondence. The scoring of Spontaneous Correspondence was accomplished by comparing the number of tiles put out by the child with the number set out by the examiner. For no difference, a full credit of 3 points was allowed on the item; a partial credit of 2 points was given for a difference of 1 or 2 tiles, and 1 point credit was given for a difference of 3, 4, or 5 tiles.

Total scores for this four item test covered the possible range of scores of 0-12. That the test was difficult for this age group is apparent from the mean score of 3.80 and a standard deviation of 2.90. Only 2 subjects had a perfect score of 12. A K-R alpha coefficient of .64 indicates satisfactory internal consistency for this brief test.

Performance on the item in which tiles were set out in a random arrangement was as good as performance on the three items of straight line arrangements. Some typical responses to both types of arrangements are shown in the figure on the attached page.

The data suggest that there may be four different categories of performance on this test. First, there are children who respond by putting out collections of tiles, either by emptying out all of the tiles, or just taking out a few handfuls. Although complying with a request to "put out" tiles, they generally do not match the examiner's arrangement in either number or configuration. Secondly, there were many children who clearly took pains to match the configuration of the examiner's tiles, but who nevertheless were not very accurate in matching number. Thirdly, there were children who clearly matched the configurations and were also fairly accurate in matching the number. Finally, there is a fourth type of performance in which the number is matched but not the configuration.

This, of course, is the way that many adults respond to the task, and this is a response that can be looked for in the performance of older children. With the possible exception of one subject, this category was missing entirely in the present data.

These results are seen as supporting Piaget's analysis that for children of this age, the correspondence of two sets is understood on a perceptual basis. That is, two sets are the same in number when they look the same, and thus the task differentiates on the basis of the precision of the child's intuitive, perceptual matching--or, to use Piaget's terms, it would distinguish between global correspondence and the more articulated intuitive correspondence.

In general, a spontaneous correspondence task would appear to be a productive, but overlooked, aspect of Piaget's work on number. A great many studies of number conservation in this country have centered on the acquisition of the operational aspect of correspondence and have tended to overlook Piaget's analysis of the interesting developments prior to conservation. In addition to its theoretical usefulness for this age group, it seems quite simple to administer--and almost always provokes a response that indicates comprehension at some level. We believe that these characteristics make it a useful technique for investigators looking at the early manifestation of quantitative thought.

Enumeration. The twelve enumeration items were scored as correct if the child pointed to each figure in the item once and only once. Incorrect responses were classified according to the type of error: omits, repeats and combinations of omits and repeats. The total scores ranged from 0-12 with a mean for the group of 6.56 and a standard

deviation of 3.57. There were no significant sex differences. The internal consistency of the test appeared good; as indicated by a K-R 20 coefficient of .86.

As might be anticipated, the difficulty of any item appeared to be a function of both the number of figures depicted in the item and the arrangement of those figures. Thus, considerably less than half the subjects passed the six items which contained 9 figures, while more than half passed the six items which contained fewer figures. The performance on the test was also influenced by the arrangement of the figures: the straight line was easiest, the ordered row next, and the random arrangement most difficult.

On the straight line items, a record was kept of the direction in which the child moved his hand while pointing to the figures. The responses were evenly divided among the three types of response--L-R, R-L, and mixed. The relationship of these responses to other measures (e.g., reading skills) could be looked at in older children.

The findings of this measure lead us to agree with Potter and Levy as to the value of a simple spatial enumeration task. It requires the child to itemize without counting and thereby permits the examiner (teacher or researcher) to look at a component of quantitative thought which is quite distinct from the ability to recite the names of numbers. The fact that over 90% of the children passed at least a few of the items, indicates that most children in this group responded with some comprehension to the task.

Counting. Counting was a one item test, and the results must be viewed as suggestive. In scoring, two distinct aspects of children's

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counting behavior were coded: (1) the child's ability to recite number names in an ascending order, and (2) the child's ability to give the right number of number names, e.g., to name seven numbers regardless of the order. About 25% of the children were correct in both respects. Another 25% recited a correct sequence (e.g., "1-2-3-4-5", or, "1-2-3-4-5-6-7-8-9") but not seven numbers. Another 20% of the subjects gave no response or said they did not know how to count, and, finally, there were a few subjects who gave 7 number names, but in incorrect order.

Relationship of tasks

The correlation between the Spontaneous Correspondence and Enumeration tasks was 0.28. As shown in the contingency table (attached), the most interesting aspect of the relationship is the fact that subjects who attained high scores on spontaneous correspondence, were by and large quite successful on enumeration. The reverse, however, does not appear to be true--the good enumerators may or may not handle the correspondence task well.

The relationship of the counting item to the two principal measures was also examined. There appears to be a clear positive relationship between counting and enumeration, since children who counted accurately were clearly above average in the enumeration task. In contrast, there appears to be almost no relationship between counting and spontaneous correspondence; if anything, the data suggest a negative relationship. The results are necessarily tentative, but they suggest that an increase in the number of counting items in a subsequent battery would be warranted. If the findings are substantiated, it would provide further evidence that

in the early years, the ability to count may bear little relationship to the child's use of number.

Discussion

It has been suggested by Kohlberg (1968) that the researcher in the field of early education might make the distinction between those abilities which appear to be outcomes of specific instruction and those abilities which are best viewed as reflecting a broader history of child-environment interaction. Piaget's tasks generally focus on the latter, and Kohlberg uses the understanding of conservation as a prime example of a concept which evolves out of such a broad history of interaction. We believe this distinction is a useful one.

In the present study, we would guess that the performance on the counting test reflects, to a great extent, some specific instructional opportunities provided by a parent, a teacher, or perhaps an educational television program. On the other hand, the performance on the spontaneous correspondence task may reflect a more elaborate history of the child's own action with objects. As such, the task indicates more about the child's construction of the environment, than it does about the specific instruction he has been given. Using this distinction, the enumeration test of the present study might fall somewhere between counting and spontaneous correspondence on this dimension, and, in fact, the intercorrelations do suggest such an ordering. An instruction-construction distinction is necessarily quite conjectural, but we believe that it can contribute to the development of a better rationale for the selection of measures for research in early education.

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Figure: Samples of Responses to Spontaneous Correspondence Task

• child
o examiner

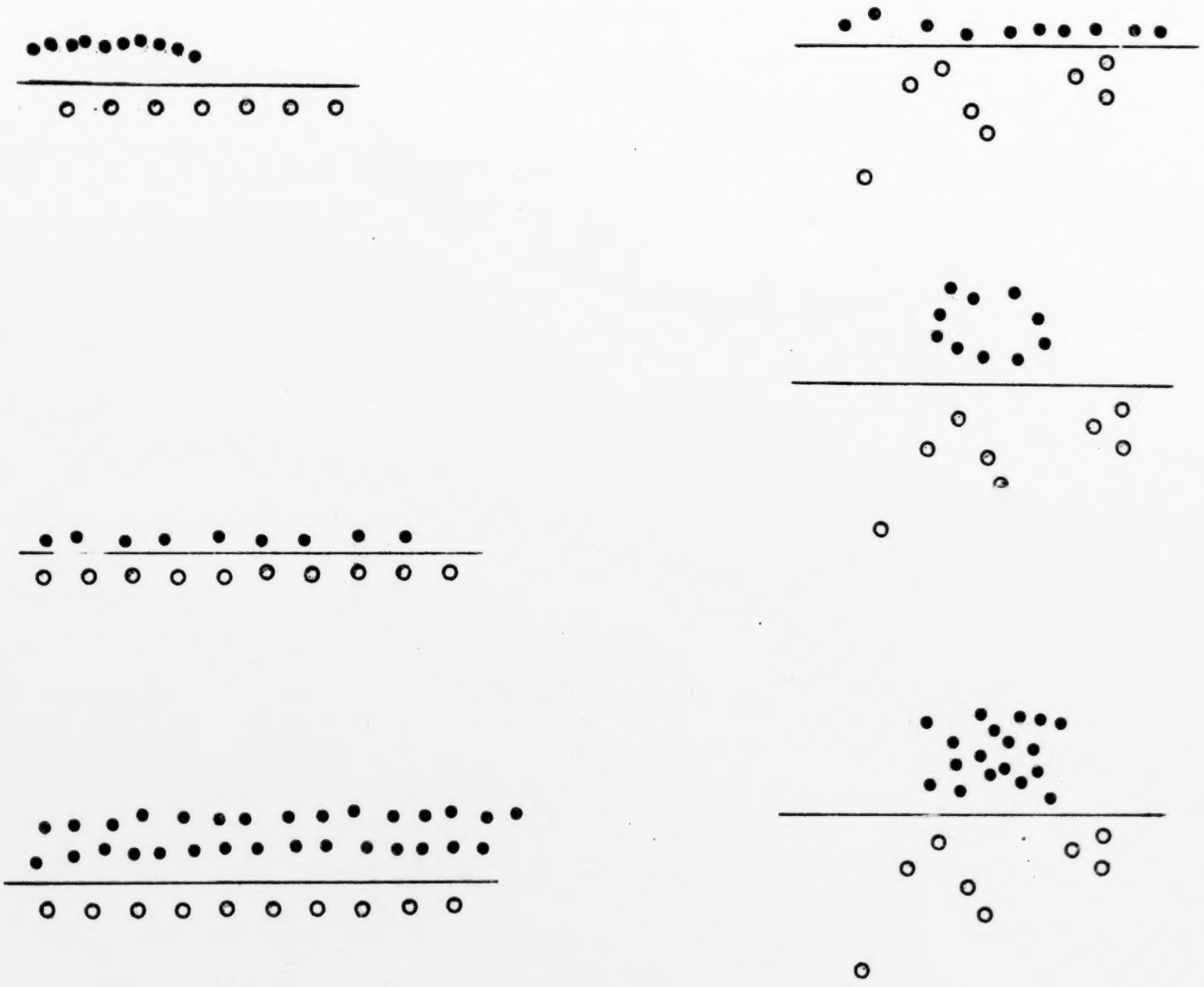

Table: Relationship between Spontaneous Correspondence and Enumeration Scores

Enumeration Scores	Spontaneous Corres. Scores		
	0-4	5-8	9-12
9-12	18	7	6
5-8	23	14	1
0-4	25	6	0